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Blinding flares - A model study of a battlefield illumination problem [R]

N. R. Williams, L.R.I.C.

Miriam Budgen

Fort Halstead.
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August 1969

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Blinding flares - A model study of a battlefield illumination problem (R)

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N. R. Williams, L.R.I.C. } E3
Miriam Budgen

5. August 1969

Summary

The Night War Game Series 1967 postulated a technique for blinding defence positions on the night battlefield. This report describes the work done, using models, which disproved the practical feasibility of this technique. The model approach was then used to determine effective methods of blinding on the battlefield and field trials carried out to enlarge on these methods. Recommendations are made for further work along the same lines, and also work to help in the design of more effective pyrotechnics generally by using models in conjunction with other techniques.

Approved for issue:

D. F. Runnicles, Principal Superintendent, 'E' Division

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1. INTRODUCTION

During a recent Night War Games Series the rules for the use of flares were written so that an observer could not normally see from a higher to a lower light level, and this led to a technique of bringing a flare down over the head of a defending observer with the aim of blinding him so that the attacking forces might advance safely across open ground. (Fig.1)

This tactic was not foreseen when the rules for the War Game were formulated, but was adopted with great enthusiasm by the visiting Commanders (of Lt. Colonel rank) who were in command of the opposing forces.[1] It offered a method of allowing their forces to keep moving at full speed on open ground, instead of coming to a stop in cover or behind self-generated smoke, when under flare-lit attack. All concerned were conscious of the vulnerability of armoured vehicles to missile attack under flare light and of the almost total invulnerability of pyrotechnic parachute flares to possible countermeasures involving destruction of the flares themselves. Later analysis of the war game data showed that because advancing vehicles were only exposed for short times, on average 33 sec., (in which time 132m. distance was covered), long range engagement was essential if armoured vehicles were to be destroyed in sufficient numbers to influence the outcome of the battle.[2] An advancing force would try to gain, first from Tactical Map analysis and later from observing the fire (if any) of the defending units, some indication of the location of defending positions at perhaps 4,000 m. They would then be able to place blinding flares accurately enough to be effective. With the short exposure time (in missile flight-time terms) of advancing forces quite short periods of blinding would be sufficient to reduce drastically the number of targets exposed long enough to complete the acquisition, aiming, firing, missile flight and strike sequences, if the adopted tactic was effective.

Against this background it was decided to investigate the phenomenon of blinding by pyrotechnic flares, and, because of the prohibitive cost of full-scale trials and considerations of the safety of observers, a first approach was made using models.

The tactic evolved during the War Game was to use flares deployed over the heads of the defending force but the model tests showed these to be ineffective and flares in line of sight were also tried. Further work was carried out in the field to test the final ideas evolved from the model experiments. No visual aids were used in any of the tests.

2. THE MODEL

A 1:100 scale model was built in two parts, one representing the target area of 400 x 800 ft. and the other representing the observation area of 400 x 800 ft. The latter was provided with an observation position on top of a hill. Both parts of the model were made to look realistic, with scaled trees, scrub,

hedges, fields, roads, etc. to represent open countryside. An observation area was considered necessary because reflection from the ground might affect blinding by flares overhead. The observer was required to look over this ground with a single eye, positioned at a man's scale height above the ground by means of a chin rest. The target area contained five vehicles, men and animals arranged in planned positions, all static, and the model was divided with white tape into six sections running from front to back. Positions within these sections were described as front, middle, back, left, centre and right. Construction details are given in Appendix A and Figs. 2, 3 and 4.

The model was constructed to give a good visual effect so that the trained military observers would feel they were in a familiar environment. Accurate representation of reflective properties of the real terrain was not essential for these comparative experiments.

Later it was possible to make optical measurements of reflectivity and target-to-background contrast with a Gamma 2,000 telephotometer. This instrument has an accurately known field of view variable in 5 steps from 2 minutes to 5 degrees of arc allowing specific surfaces of the model vehicles to be examined. Reflectivity was measured by comparison with a magnesium carbonate block, which was assumed to be a perfect diffuser, placed at the same position and angle as the surface being measured, while blotting paper was used as a substandard calibrated from the magnesium carbonate. Measurements were also taken in the field of natural vegetation and terrain and Army vehicles.

Target-to-background contrast measurements are described in Appendix B. The reflectivities of the models agreed well with those of the actual vehicles and terrain except for trees. (Table 1). The discrepancies here may be due to lack of leaves on the models, which allowed light to pass through, and the effect of leaf movement on the real trees which continually varied the luminosity.

3. EXPERIMENTS WITH THE MODEL

Experiments were designed to compare the probability of an observer seeing targets, during a search task, when the targets were illuminated in the normal way by a pyrotechnic parachute flare and when a blinding flare was also alight.

The flares were simulated by tungsten filament light bulbs. For steady overhead flares the lights were chosen to give the desired illumination on the ground from a scaled height to represent a typical illuminating flare, e.g. 250,000 candelas at 800 ft. These bulbs were static and the swing, flicker, drop and drift of a parachute flare were not represented. All single blinding "flares" were placed in a vertical plane through the observer and the centre of the target model. In different experiments several positions of blinding "flare" were used, from directly overhead to just above the line of sight between the observer and target, (Fig. 9 - positions 1-4). A flickering green "flare" was used in one series because it is reported that green lights attract attention and flickering lights confuse.[3] The rate of flicker and colour were chosen to agree with an

actual flare composition performance, (Potassium metaborate, magnesium, barium nitrate, alloprene, resin) which flickered at approximately 3 cycles/sec. The maximum candlepower was about one third of that of the steady "flare".

In another series of experiments lights were placed directly in the line of sight mid-way between the observer and target areas and comparison of observer performance, with and without these lights, was made as before. Steady lights only were used in these experiments, (Fig. 9 - position 5).

Some experiments were included in which eye shades and tubes were provided in an attempt to mask the blinding flare but these had little effect.

A group of six civilian staff of wide age range and of both sexes and two groups of five young soldiers were put through the following experiments.

All the observers were allowed to take a close look at the model and the vehicles and the points of interest were indicated. All were dark-adapted for twenty minutes, then positioned at the observation post one at a time to look at the target terrain at a simulated range of 1,000 m. The illuminating flare was switched on for two minutes and the observer asked to search in a systematic way from foreground to background, and from the left-hand section to the right-hand section in order, reporting his observations to a tape-recorder giving the detection, identification or recognition and position of the target. Four pre-set layouts of targets were used but the observers did not know this. (Figs. 5, 6, 7 and 8.). After a period of days the observers were again dark-adapted and positioned at the observation post but this time a blinding "flare" was lit at the same time as the illuminating "flare" and the same task was performed as before.

4. RESULTS AND DISCUSSION

All the tape records were analysed and converted into result sheets of which two typical examples are reproduced in Tables 2 and 3.

For the purposes of this paper, the following definitions have been used:-

D : detection: observing the presence of an unspecified object different from the terrain. In the result sheets these have been related to the specified objects which were at the positions indicated.

C : classification: observing the nature of the object, e.g., man, tank.

R : recognition: observing detail such as direction of object.

In each instance the time is given for only the more complete observations; "recognition" implies that the object had already been detected and classified.

There were many examples of detection of objects which could not be identified within the two minutes allowed. There were many instances where objects were wrongly identified.

The whole of the experiments are summarised in Table 4. Inspection of the result sheets showed that no useful effect was produced by overhead flares, whether steady or flickering.

These conclusions were confirmed by statistical analysis of a representative group of results. For this purpose the counter-flare tactic was best assessed on the following measurements of observer performance:-

(a) the number of vehicle targets detected, bearing in mind the number of false detections.

(b) the time to the first detection of a vehicle target.

(c) and (d) as for (a) and (b) but using the criterion of "classification" instead of "detection".

There were too few "recognitions" for analysis. The results which were analysed are collected together in Tables 5, 6, 7 and 8.

Because the counter-flare position was associated with a particular target layout, comparisons between counter-flare positions were made by using the state "no counter flare" as a control, as this was used with all layouts.

Eash layout had 5 targets so that six observers produced enough observations for the experiment to be capable of revealing any effect of the counter-flare great enough to be of practical interest.

In Tables 5 and 7 the variations for the various lighting conditions and the number of false detections and classifications over all layouts is slight and could have been due to chance, therefore false observations can be ignored when comparing the conditions of illumination with respect to the number of vehicles detected or classified.

The blinding effect of lights overhead was not great, and lights near the line of sight could be covered or shielded from the eye easily. There was some indication that the extra illumination from the blinding light aided the detection of certain targets which reflected frontal illumination well. The flickering light gave no significantly different results from the steady blinding lights.

A single light on the line of sight between observer and the middle of the target terrain degraded the observer performance over an angle of about 20°, but the angle could be reduced by covering the source of the light with an

object in front of the eye. Three flares in a line at right angles to the line of sight degraded the observer performance dramatically over the whole target terrain, and it was not possible to cover all three lights so as to see past them. Figure 10 summarises briefly the effect of the flare position.

5. FIELD TRIALS

To test under field conditions this blinding, or obscuring, property of lights in the line of sight on the Battlefield night trials were conducted on the Langhurst range using the same groups of civilians and soldiers as in the simulation work. An illuminating flare was placed 45 ft. high on a tower to give 0.2 to 0.3 foot-candles on the ground over an area in which was positioned a tank to be silhouetted by the flare, (Fig. 11). Various other buildings and vehicles were in the vicinity giving a wide angle of search from the observation points. White posts were also placed to help in assessing angles of obscuration. The observers stood along a line as shown at about 840 ft. range and approximately mid-way between the observers and the targets were positioned the various blinding devices. Smokes were included in some trials. These devices were:-

1. A single flare burning flame upwards on the ground.

2. Three flares in a row on the ground at right angles to the line of sight, flame upwards.

3. Three smoke grenades, Type L7A1 green, as used in the vehicle smoke discharger, arranged in the same way as the flares.

4. Two smoke grenades and one flare, with the flare between the smokes to give illuminated smoke.

These positions are shown diagrammatically in Fig. 12.

The observers were asked to say what they could see when:-

1. The illuminating flare only was alight.

2. The blinding device was lit.

3. The blinding device stopped operating and the illuminating flare continued to burn.

The analysis of these limited trials showed that very effective obscuration was achieved using flares only, one flare gave obscuration of a 20° arc and three flares gave obscuration of a 30° arc, but the greatest effect was produced by the combination of smoke and flame because reflection from the smoke particles enlarged the effect of both smoke obscuration and light blinding. Smoke only was not effective at this distance because it quickly drifted away, and often did not rise high enough to hide completely what was behind it.

6. RECOMMENDATIONS FOR FUTURE WORK

6.1 Further work is necessary to evaluate fully the usefulness of blinding systems. The positions, numbers, size and intensity of the flares and smokes should be varied to determine the optimum conditions. Perhaps a very smoky flare composition would be effective.

6.2 Other vehicles should be observed both moving and static; also it is essential to determine the feasibility of continuous driving behind such a screen. During the experiments already conducted an observer in the target tank reported that the light produced by the flares was sufficient to drive across the ground towards the blinding flares.

6.3 Experiments are needed to find the optimum distance ahead of the blinding screen with regard to speed of movement of the vehicle so that the screen could be renewed in advance of the vehicle.

6.4 Burning times of screening flares require careful consideration in order to reduce the possibility of self-illumination.

6.5 Observations over longer ranges up to the maximum missile ranges should be made.

6.6 Flares of various colours should be tested in an effort to reduce the atmospheric scatter problem and yet give sufficient light. In the past it has been accepted that the brightest compositions should be used for illuminating flares, which necessarily leads to white or yellow light.

6.7 Flares of varying brightness - periods of very bright light followed by lower light level - might be more effective in revealing targets to human observers since it is found that looking away from the target area periodically improves the certainty of detection.[4]

6.8 The effectiveness of flares might be improved by using other configurations such as opposed candles and shaped burning surfaces which do not have the disadvantage of the conventional parachute flare - sideways radiation due to downward pointing flame with smoke at its tip. The light distribution could be determined with the Langhurst spatial radiation measurement rig, and its relevance to battlefield illumination found by specially masked light sources on the model.

6.9 The effect of parachute movement on target recognition should be investigated. A model rig has been constructed to simulate drift and fall. The results of such a study would be important with regard to the investigation of parachute stability and fall being carried out under contract by Irvine Air Chute Ltd. It is possible that movement of the flare is important to the recognition of targets and should not be reduced below an optimum value. This could be decided by means of model experiments.

6.10 A combination of model and spatial radiation rig experiments could be

used to investigate the periodic variation in output shown by photometric records which is often attributed to parachute swing and/or smoke effects.

7. ACKNOWLEDGMENTS

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APPENDIX A

CONSTRUCTION DETAILS OF THE 1:100 SCALE MODELS

A cheap and quick method of constructing models was sought which would give a good visual effect on trained soldiers, so that they felt happy with their task and not too removed from familiar surroundings. It was also aimed to pitch the task so that with realistic light levels of illumination something like a 50% probability of detection of targets was achieved. A degradation or improvement in performance of the observers would then be obvious. A scale of 1:100 was decided on thus giving a maximum range of 1,200 metres in the building available.

Two standard 8' x 4' hardboard sheets were strengthened with wood frames to form the basis of the two parts of the model, keeping the rough side of the hardboard uppermost to provide the surface of the models. These were stood on Dexion trestles to give the appropriate relative height of observation and target areas. An imaginary terrain 400' x 800' was built up on the target area hardboard base to represent a hill with a footpath, a road, a farmstead, trees, hedges, stone walls, ploughed land and grassland. This was typical of the gradients and hills shown on the Ordnance Survey map of the Salisbury Plain area. The foundations of the hill were built up from blocks of expanded rigid polystyrene stuck with Black Bostik Adhesive and shaped by cutting. This foundation was covered with sacking, so as to reproduce the texture of grass and the sacking painted with brilliant green paint GA. 6045 leaving a footpath bare of paint. Other areas were painted brown GA. 6043 to simulate ploughed fields the effect being aided by the rough hardboard surface. Hedges and scrub were made of foamed rubber type material cut into strips and shapes, stuck on, and painted green after being roughened by pulling pieces off. Stone walls were represented by the same material left in its natural stone colour and with a straight-cut surface. Five scale model toy vehicles were used as targets. These were of self-coloured plastic in matt 'bronze green'.

The models were three Russian T. 10 tanks, a 3-ton covered lorry and a self-propelled gun. Trees were scale model toys stuck down and scale model animals and soldiers were used to give realism to the scene and provide some confusion. A farmstead was made of polystyrene blocks cut to shape and painted, and a road was painted on with black paint and hedged.

A similar, but simpler, terrain was built up in the same way on the 'observation area' hardboard base to provide a look-out position from a good vantage point on the top of a hill. A chin-rest was provided, so that the observer's eye was in the correct scale position, on top of the hill. The observer was allowed to use one eye only to ensure that a false perspective effect could not operate, since the actual range distance was one hundredth of the range being simulated, so that two eyes would have represented two men thirty feet apart.

APPENDIX B

TARGET TO BACKGROUND CONTRAST MEASUREMENTS

Target to background contrast, C, is defined as

$$C = \frac{LT - LB}{LB}$$ where LT is luminance of target
LB is luminance of background

It was of interest to determine the contrast of each model vehicle in every position used in the 4 layouts under all lighting conditions but due to the large number of combinations of position and lighting arrangements, it was practical to measure contrast for one layout only. The vehicles were therefore placed in position for layout 1 and viewed using the different lighting systems. Results were as follows:-

(a) illuminating flare above target area only, (slightly behind targets). All vehicles had a negative contrast under these conditions with contrasts as high as -0.93. (Maximum possible negative contrast is -1.0 when target is matt black). Some of the curved, almost horizontal, sections of the vehicles such as parts of the tank turrets had contrasts of -0.11.

(b) illuminating flare above target area and steady counter flare in position 1, (5ft 2ins. above observer's eye). All parts of vehicles that were measured had a negative contrast of generally smaller values than in case (a) with the exception of the lower part of a tank turret which was curved and which had a positive contrast compared with the wall behind it. Thus this tank was diadic as the remainder of the vehicle had a negative contrast.

(c) illuminating flare above target area and steady counter flare in position 2, (5ft 10ins. above observation area and in front of observer). These results indicated slightly more negative contrast in all cases than with conditions (a) or (b).

(d) illuminating flare above target area and steady blinding flare in position 3, (2ft above observation area, in front of observer). This again gave high values of negative contrast similar on average to those obtained under the conditions of (c) above.

(e) illuminating flare above target area and steady counter flare in position 4 (slightly above line of sight mid-way between target and observer). In all cases, the contrast was less than in (d) above. The top of the lorry which simulated canvas gave a positive contrast so that the lorry was a diadic target.

(f) illuminating flare above target area and one simulated flare (15W lamp) central on the line of sight in position 5. This gave negative contrast values varying from -0.38 to -0.85.

(g) illuminating flare above target area and three simulated

flares mid-way along the line of sight and symmetrical about it. This reduced the contrast obtained under (f) above and some nearly horizontal surfaces gave positive contrast, (e.g. tank turret and lorry roof).

Notes on the methods of measurement

The geometrical layout was as follows:-

1. Conditions (a) (b) and (c) -

Telephotometer mid-way between observer and centre of target (i.e. 5 metres from target).

2. Conditions (d) and (e)

Telephotometer at observer position (10 metres) with light shield attached. Six minute field of view covers larger area of target from this position than was viewed from the above position.

3. Conditions (f) and (g)

Telephotometer head 5 metres from centre of target area and slightly to the right with light shielf attached to prevent light from the counter flare entering the instrument directly.

The background illumination in the building was measured with no artificial illumination. The telephotometer was directed towards the model and the luminance measured was 0.14×10^{-4} foot Lamberts.

The opportunity was taken to measure the candlepower of the illuminating flare by measuring the illumination on the ground and this was found to agree with the value obtained by calibration on an optical bench using a standard photometer lamp. Thus the nominal 25 watt light bulb gave 0.3 foot-candles at the centre of the target area.

TABLE 1

REFLECTIVITIES MEASURED WITH GAMMA 2,000 TELEPHOTOMETER

Object	Measurements on Model		Measurements in field	
	Reflectivity %	Remarks	Reflectivity %	Remarks
Tank	11.3, 11.4	1st model	8.1, 17.4	
	12.5, 12.6 14.0	2nd model		
	11.0	Turret	14.3, 10.4	Turret
			13.8	Hub Cap
Lorry	12.7	Side	12.9, 12.8	Side
	13.0	Roof	18.4, 19.8	Green Canvas/ Tarpaulin
Trailer			7.05, 8.35 8.7	Green painted
Self-propelled gun	13.4	Back engine cover		
	28.0	Side (grass visible through wheels)		
Grass	18.5, 20.0	Painted sacking	20.0	New sown
	20.4	Painted hardboard (rough)	11.4, 12.9 10.2	Other grass
Scrub	8.1, 11.9		11.9	
Wall	45, 50, 50, 44		56	Concrete blocks
			30.7	Dirty concrete blocks
Ploughed field	20, 20.3	Painted hardboard (rough side)	18.3	Light mud
			12.2	Dark mud
Hedge	32.5, 37.5			
Trees	59	Thin	5.7, 9.5	Beech
	43.5	Fir		
	62.5	Thick	28, 22	Hawthorn
			17.7, 16.8	Sallow

$$\text{Reflectivity \%} = \frac{\text{Light reflected by object} \times 100}{\text{Light reflected by perfect diffuser}}$$

TABLE 2

Experiment: No.32
Layout: No. 4
Counterflare: None
Date: 22.4.68.

MODEL BATTLEFIELD OBSERVATIONS

TYPICAL RESULT SHEET

Model Section	Position	Object	Time, in seconds, to detection (D), classification (C) or recognition (R) by:																	
			Observer No.1			Observer No.2			Observer No.3			Observer No.4			Observer No.5			Observer No.6		
			D	C	R	D	C	R	D	C	R	D	C	R	D	C	R	D	C	R
1	front middle, right middle, centre	4 men 3 cattle lorry	-	17					-	8		- -	20 10		11 -	18		29		
2	middle, centre middle, centre	3 men 3 cattle				- -	30 30		19 19			33 33			45 45			36 36		
3	front, left front, right middle, right	tank 3 men tank	47			- -	40 35		107 - 43	80		- -	- 47	39	- - 72	60 85	-	-	-	82
5	middle, left back	3 men 10-20 men	-	90		- -	70 74					- -	- 86	77	-	105				
6	middle, centre middle, centre back, right	S.P.G. 4 cattle tank	-	102		83 - 97	86		90 88			103 -	-	95	116			105		
1 2 3 4 5 6			False observations Men, front (5) tank, middle right (6)			tank (2)			vehicle, middle, right (5)			lorry, middle (4)			vehicle, front (1) tank (2) vehicle, back, right (3) vehicle, front (4) cattle, front (6)					

NOTE: 1. For definitions see Section 4

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TABLE 3

Experiment: No.40
Layout: No. 4
Counterflare: Position 4
Date: 1.5.68.

MODEL BATTLEFIELD OBSERVATIONS

TYPICAL RESULT SHEET

Model Section	Position	Object	Time, in seconds, to detection (D), classification (C) or recognition (R) by:																	
			Observer No.1			Observer No.2			Observer No.3			Observer No.4			Observer No.5			Observer No.6		
			D	C	R	D	C	R	D	C	R	D	C	R	D	C	R	D	C	R
1	front middle, right middle, centre	4 men 3 cattle lorry	15 -	19		28			10			16 24			11 84			- 95	10	
2	middle, centre middle, centre	3 men 3 cattle	30 30			59 59														
3	front, left front, right middle, right	tank 3 men tank	40			-	75		-	43		44			33 30			22		
5	middlo, left back	3 men 10-20 men	-	103								- ..	-	66	-	58				
6	middle, oentre middle, centre back, right	S.P.G. 4 cattle tank	- - 110	90 86		115			96 -	87		- 100	77		64 -	69		53 60		
			False Observations																	
2 3 4 5			Vehicle middle, right lorry, front Vehicle, middle, right			-			Vehicle, middle, right						Tank, middle vehicle, front Men, middle Vehicle, middle					

NOTE:. " For definitions see Soction 4

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TABLE 4

TOTAL NUMBER OF OBSERVATIONS

(ILLUMINATING FLARE IN POSITION EVERY TIME)

Counter Flare		Other Conditions	Number of Observations	
Type	Position		Civilian	Soldier
None			76	115
Steady	1		6	10
"	2		6	-
"	3		5	10
"	4		6	10
Flickering	1		6	-
"	2		6	-
"	3		6	-
"	4		6	10
Line of sight Steady	5	1 flare	6	20
		3 flares	12	20
None		Looking through viewing tube	-	11
"		Using both eyes	-	11
"		Using both eyes and eye-shades	-	11
"		Using binoculars	4	5
		TOTAL	145	233

TABLE 5

SUMMARY OF RESULTS USED FOR STATISTICAL ANALYSIS

NUMBER OF VEHICLE TARGETS DETECTED

(Totals for all observers)

Section	1	2	3	4	5	6	Total all Sections	Total false detections
Layout 1 (Counter-flare in position 1)								
Maximum possible	6	-	-	12	6	6	30	
No counter-flare	4	-		11	5	2	22	3
Flickering counter-flare	4			11	5	6	26	7
Steady counter-flare	6			10	6	5	27	3
Layout 2 (Counter-flare in position 2)								
Maximum possible	-	-	12	6	6	6	30	
No counter-flare			7	3	5	4	19	7
Flickering counter-flare			9	6	5	5	25	5
Steady counter-flare			7	6	6	6	25	6
Layout 3 (Counter-flare in position 3)								
Maximum possible	10	5	10	-	-	-	25	
No counter-flare	6	4	8				18	6
Flickering counter-flare	6	4	7				17	8
Steady counter-flare	6	4	9				19	4
Layout 4 (Counter-flare in position 4)								
Maximum possible	6	-	12	-	-	12	30	
No counter-flare	1		8			7	16	8
Flickering counter-flare	1		6			8	15	8
Steady counter-flare	4		7			7	18	7
Layout 1 (Counter-flare in position 5)								
Maximum possible	6	-	-	12	6	6	30	
No counter-flare	6			11	5	6	28	2
3 steady counter-flares	1			3	6	1	11	6

TABLE 6

SUMMARY OF RESULTS USED FOR STATISTICAL ANALYSIS

TIME (seconds) TO FIRST DETECTION OF A VEHICLE TARGET

(Model Section number in parenthesis)

Observer -	1	2	3	4	5	6	Median
Layout 1 (Counter-flare in position 1)							
No counter-flare	24(1)	12(1)	48(4)	20(1)	20(1)	10(5)	20
Flickering counter-flare	41(4)	8(1)	14(1)	10(1)	13(1)	26(4)	13½
Steady counter-flare	10(1)	9(1)	21(1)	12(1)	13(1)	17(1)	12½
Layout 2 (Counter-flare in position 2)							
No counter-flare	32(3)	40(3)	25(3)	42(3)	40(3)	36(4)	38
Flickering counter-flare	27(3)	31(3)	34(3)	34(3)	46(3)	22(3)	32½
Steady counter-flare	35(3)	52(3)	30(3)	41(3)	42(3)	23(3)	38
Layout 3 (Counter-flare in position 3)							
No counter-flare	Excluded	9(1)	15(1)	11(1)	18(1)	15(1)	15
Flickering counter-flare	Excluded	8(1)	13(1)	7(1)	9(1)	22(3)	9
Steady counter-flare	No record	15(1)	13(1)	10(1)	15(1)	29(1)	15
Layout 4 (Counter-flare in position 4)							
No counter-flare	47(3)	40(3)	43(3)	47(3)	60(3)	82(3)	47
Flickering counter-flare	44(3)	71(6)	33(3)	47(3)	29(3)	29(6)	39
Steady counter-flare	19(1)	75(3)	43(3)	24(1)	30(3)	22(3)	27
Layout 1 (Counter-flare in position 5)							
No counter-flare	12(1)	15(1)	14(1)	8(1)	15(1)	9(1)	13
3 steady counter-flares	44(5)	42(4)	110(5)	38(4)	31(1)	35(5)	41

TABLE 7

SUMMARY OF RESULTS USED FOR STATISTICAL ANALYSIS

NUMBER OF VEHICLE TARGETS CLASSIFIED

(Totals for all observers)

Section -	1	2	3	4	5	6	Total all Sections	Total False Classifications
Layout 1 (Counter-flare in position 1)								
Maximum possible	6	-	-	12	6	6	30	2
No counter-flare	2			6	1	1	10	
Flickering counter-flare	1			7	2	3	13	2
Steady counter-flare	1			7	2	4	14	-
Layout 2 (Counter-flare in position 2)								
Maximum possible	-	-	12	6	6	6	30	
No counter-flare			3	-	3	1	7	2
Flickering counter-flare			2	-	3	2	7	2
Steady counter-flare			3	2	2	3	10	3
Layout 3 (Counter-flare in position 3)								
Maximum possible	10	5	10	-	-	-	25	
No counter-flare	4	-	4				8	2
Flickering counter-flare	1	-	3				4	-
Steady counter-flare	2	-	2				4	-
Layout 4 (Counter-flare in position 4)								
Maximum possible	6	-	12	-	-	12	30	
No counter-flare	-		4			1	5	4
Flickering counter-flare	-		4			1	5	4
Steady counter-flare	1	2	2			1	4	2
Layout 1 (Counter-flare in position 5)								
Maximum possible	6	-	-	12	6	6	30	
No counter-flare	2			9	1	2	14	-
3 steady flares				1			1	-

TABLE 8

SUMMARY OF RESULTS USED FOR STATISTICAL ANALYSIS

TIME (seconds) TO FIRST CLASSIFICATION OF A VEHICLE TARGET

(Model section number in parenthesis)

Observer –	1	2	3	4	5	6	Median
Layout 1 (Counter-flare in position 1)							
No counter-flare	24(1)	12(1)	48(4)		61(4)	10(5)	36
Flickering counter-flare	41(4)	8(1)	47(4)	38(4)	75(6)	59(5)	44
Steady counter-flare	80(4)	72(4)	59(4)	54(4)	13(1)	54(4)	56
Layout 2 (Counter-flare in position 2)							
No counter-flare	32(3)	76(5)	26(3)		40(3)		58
Flickering counter-flare	86(5)	63(5)		45(3)		110(3)	98
Steady counter-flare	60(4)	60(3)	30(3)	54(3)		60(3)	60
Layout 3 (Counter-flare in position 3)							
No counter-flare	Excluded	9(1)	15(1)	53(3)		15(1)	15
Flickering counter-flare	Excluded			39(3)	9(1)	22(3)	39
Steady counter-flare	No record	26(1)	57(3)	45(3)	15(1)	91(5)	45
Layout 4 (Counter-flare in position 4)							
No counter-flare	102(6)	40(3)		47(3)	60(3)	82(3)	71
Flickering counter-flare		113(3)	33(3)	89(6)	29(3)		101
Steady counter-flare	19(1)	75(3)	43(3)				>75
Layout 1 (Counter-flare in position 5)							
No counter-flare	41(4)	15(1)	62(4)	58(4)	15(1)	41(4)	41
3 steady counter-flares				38(4)			>38

FIG. I

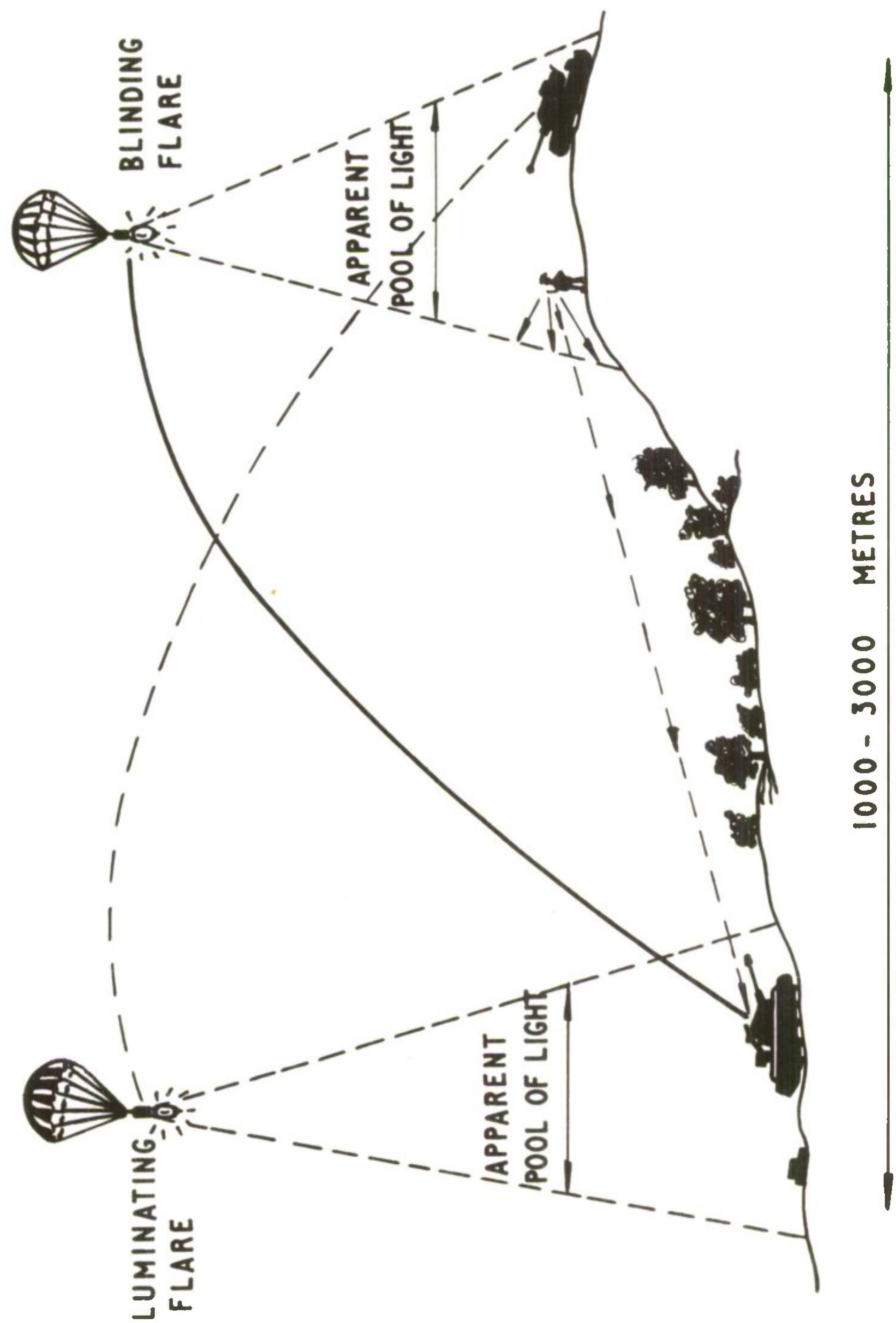

FIG. I SUGGESTED USE OF BLINDING FLARE

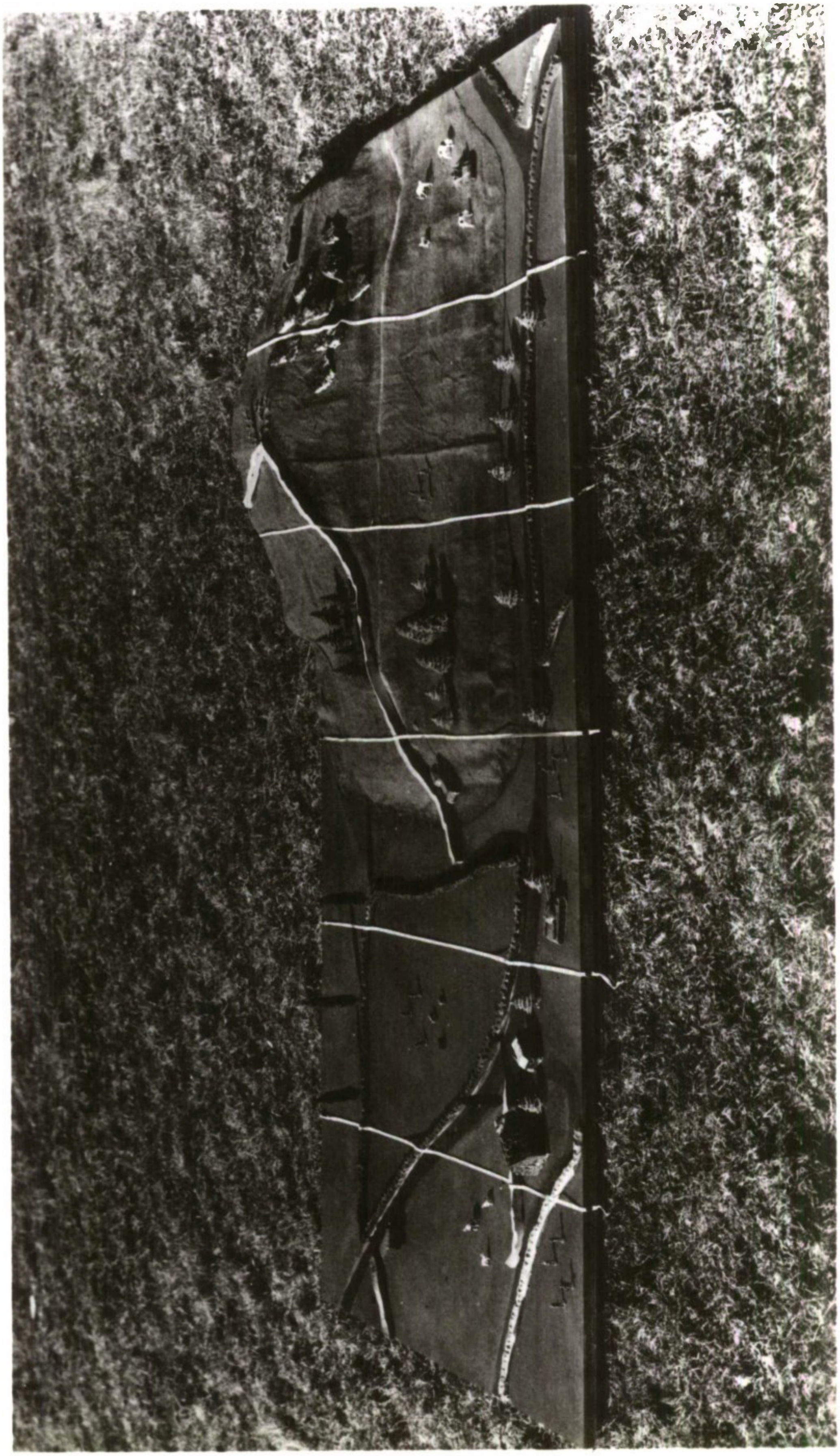

FIG. 2 MODEL OF TARGET AREA

FIG. 3 MODEL OF OBSERVATION AREA

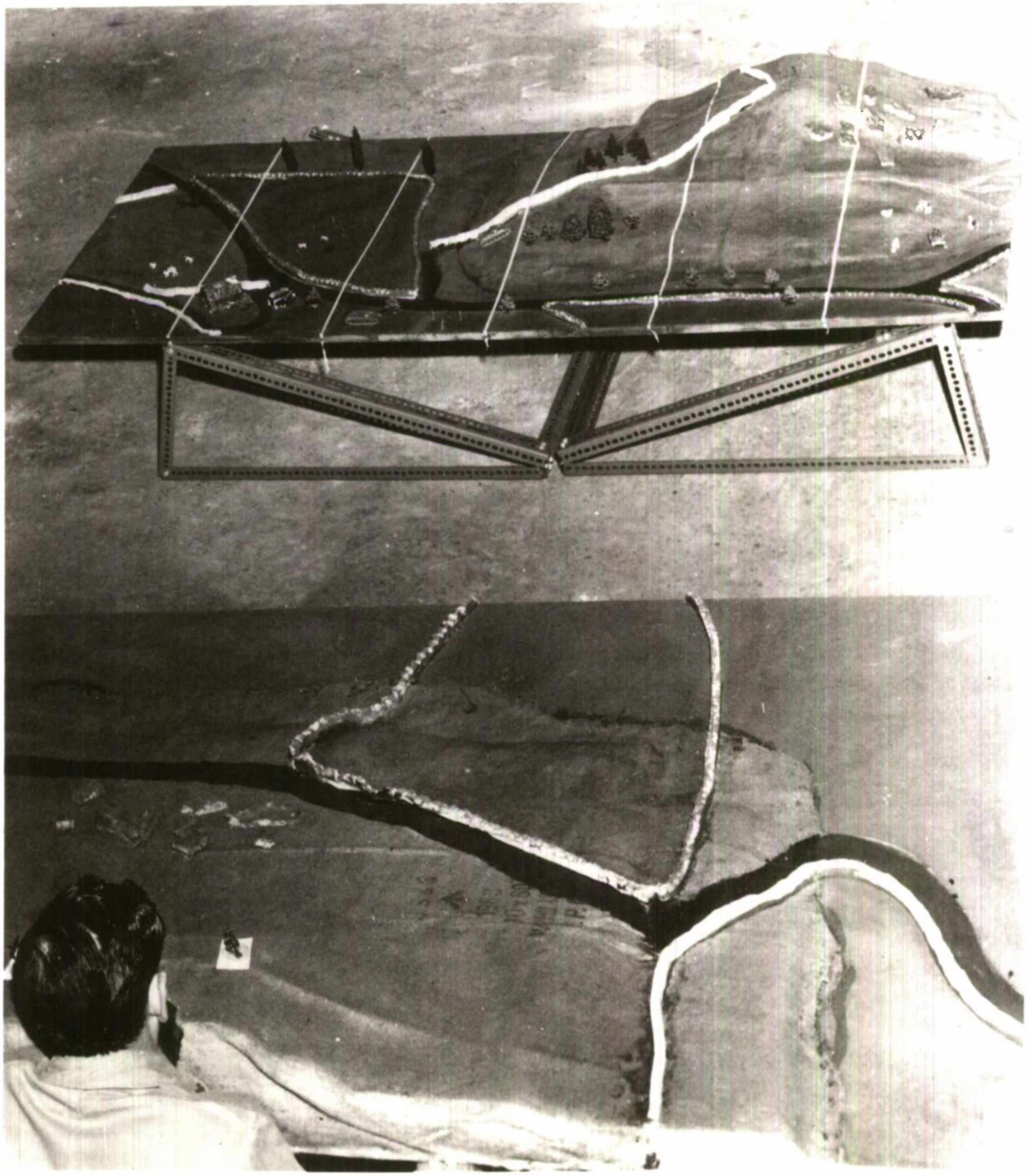

FIG. 4. MODEL IN USE

FIG. 5

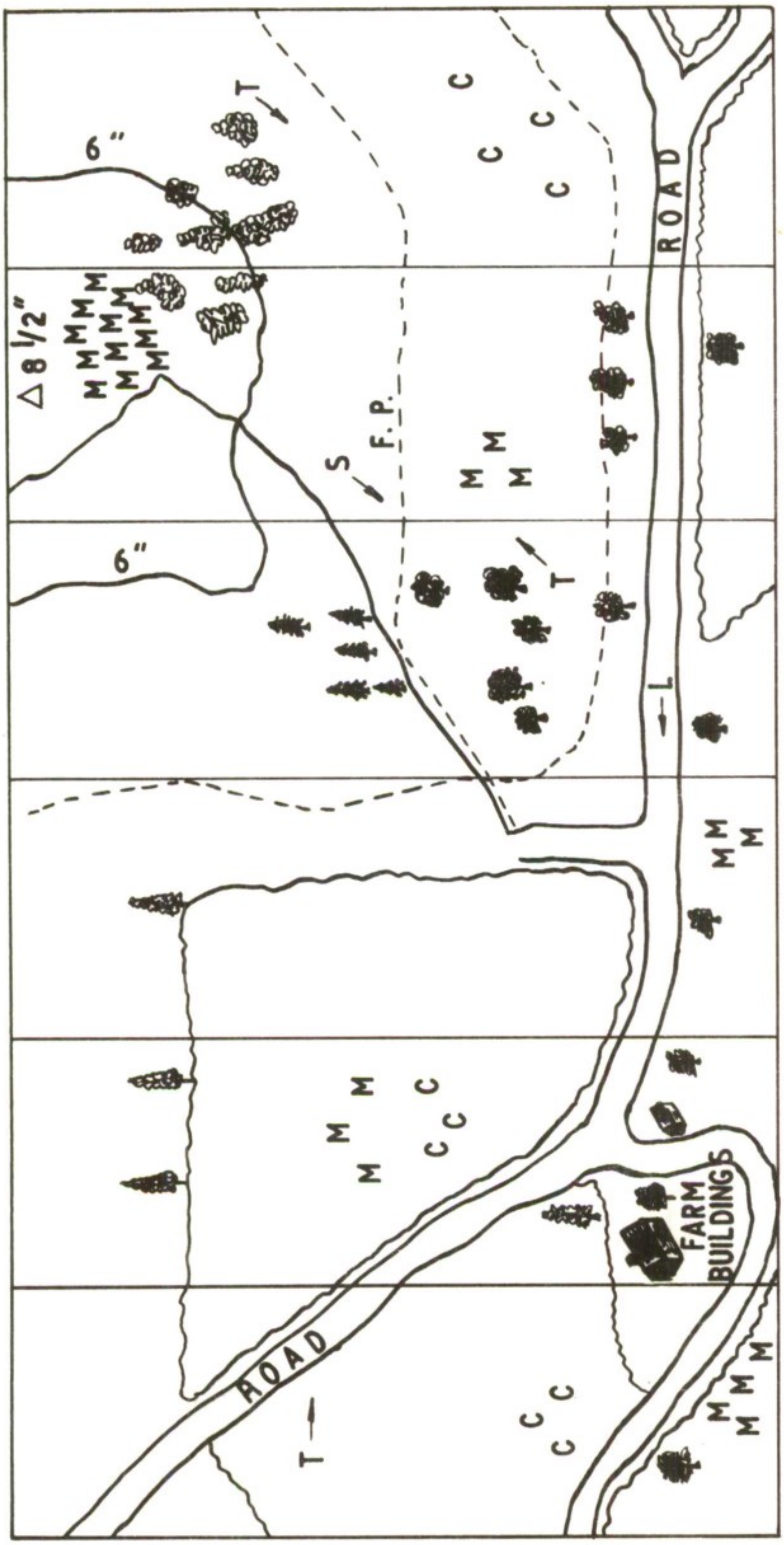

FIG. 5 MAP OF MODEL SHOWING LAYOUT No. 1
(SCALE:- 1 IN. TO 1 FT.)

KEY	
C	CATTLE
L	LORRY
M	MEN
S	SELF-PROPELLED GUN
T	TANK
F. P.	FOOT - PATH

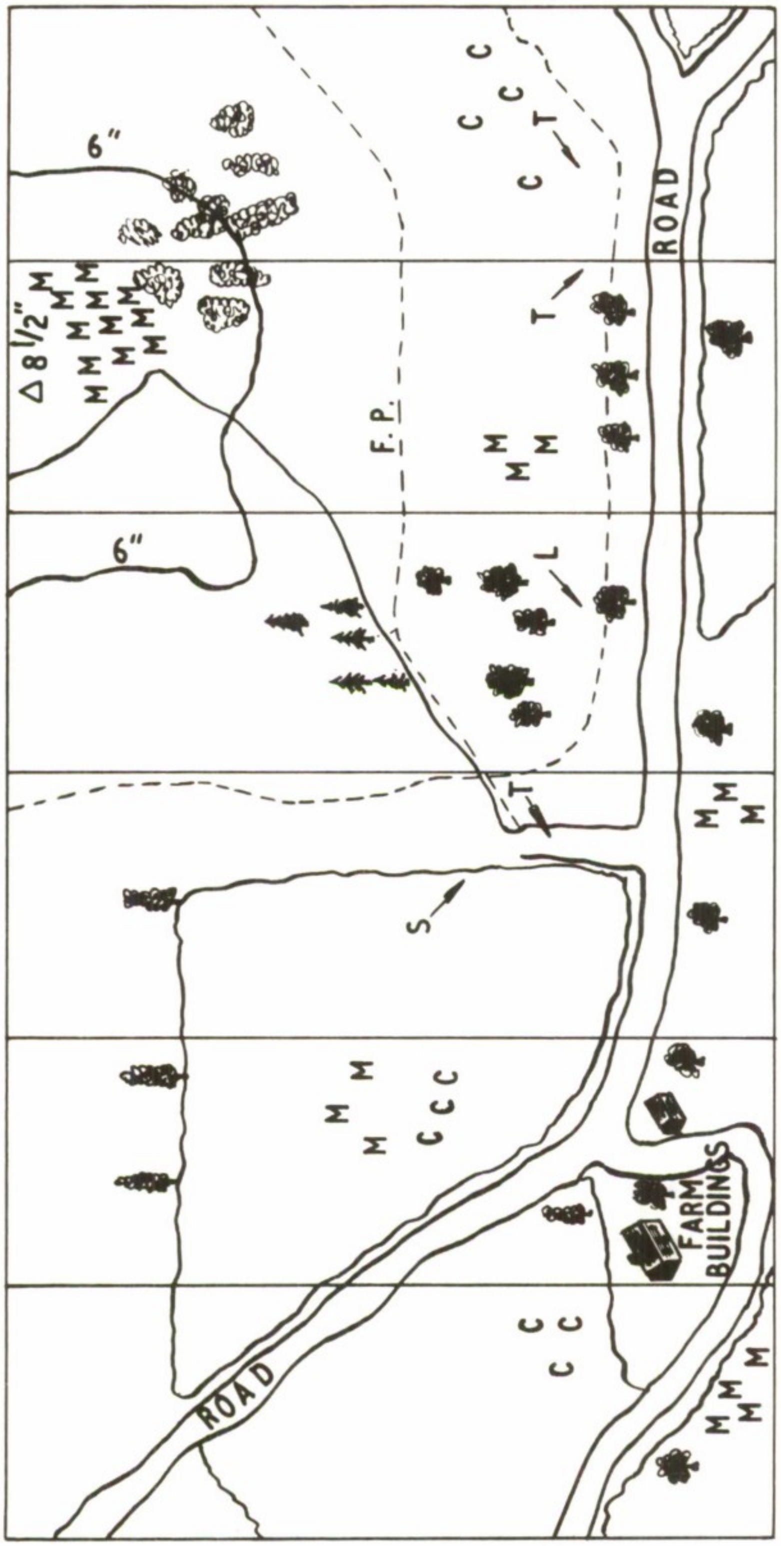

FIG. 6 MAP OF MODEL SHOWING LAYOUT No. 2

(SCALE:- 1 IN. TO 1 FT.)

KEY	
C	CATTLE
L	LORRY
M	MEN
S	SELF-PROPELLED GUN
T	TANK
F. P.	FOOT-PATH

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FIG. 7

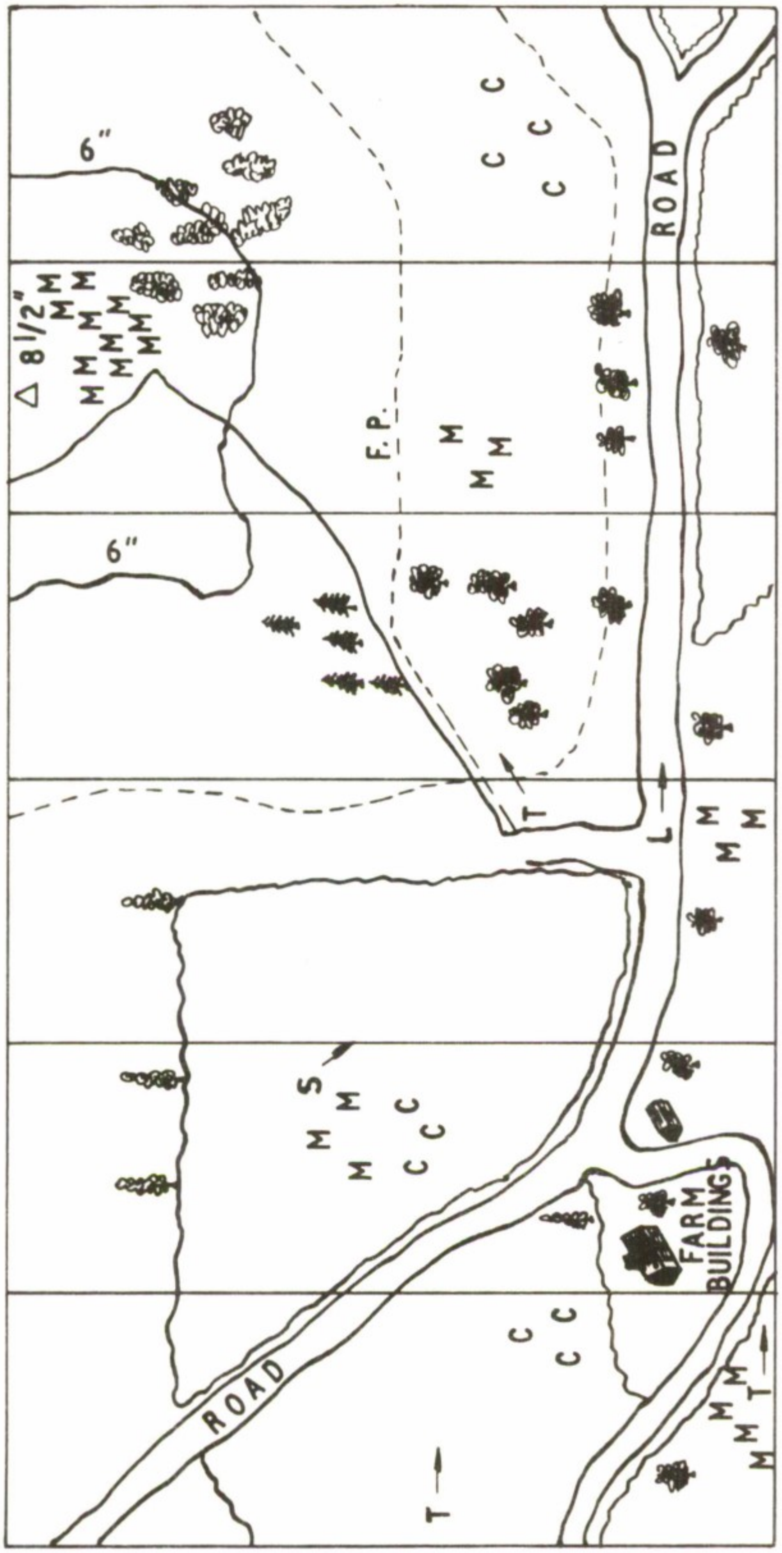

FIG. 7 MAP OF MODEL SHOWING LAYOUT No. 3

(SCALE:- 1 IN. TO 1 FT.)

KEY	
C	CATTLE
L	LORRY
M	MEN
S	SELF-PROPELLED GUN
T	TANK
F.P.	FOOT-PATH

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FIG. 8

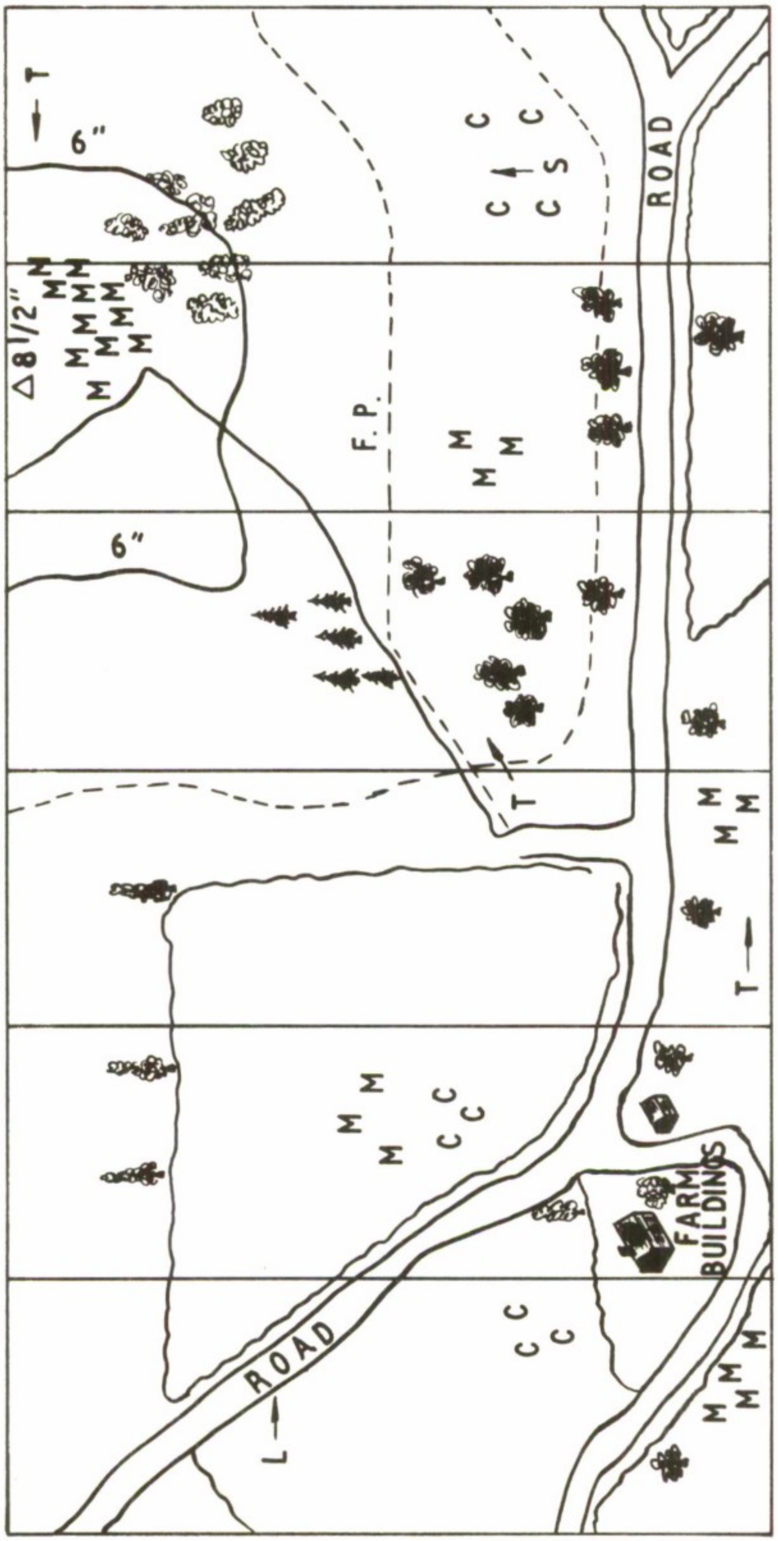

FIG.8 MAP OF MODEL SHOWING LAYOUT No. 4

(SCALE:- 1 IN. TO 1 FT.)

KEY	
C	CATTLE
L	LORRY
M	MEN
S	SELF-PROPELLED GUN
T	TANK
F.P.	FOOT-PATH

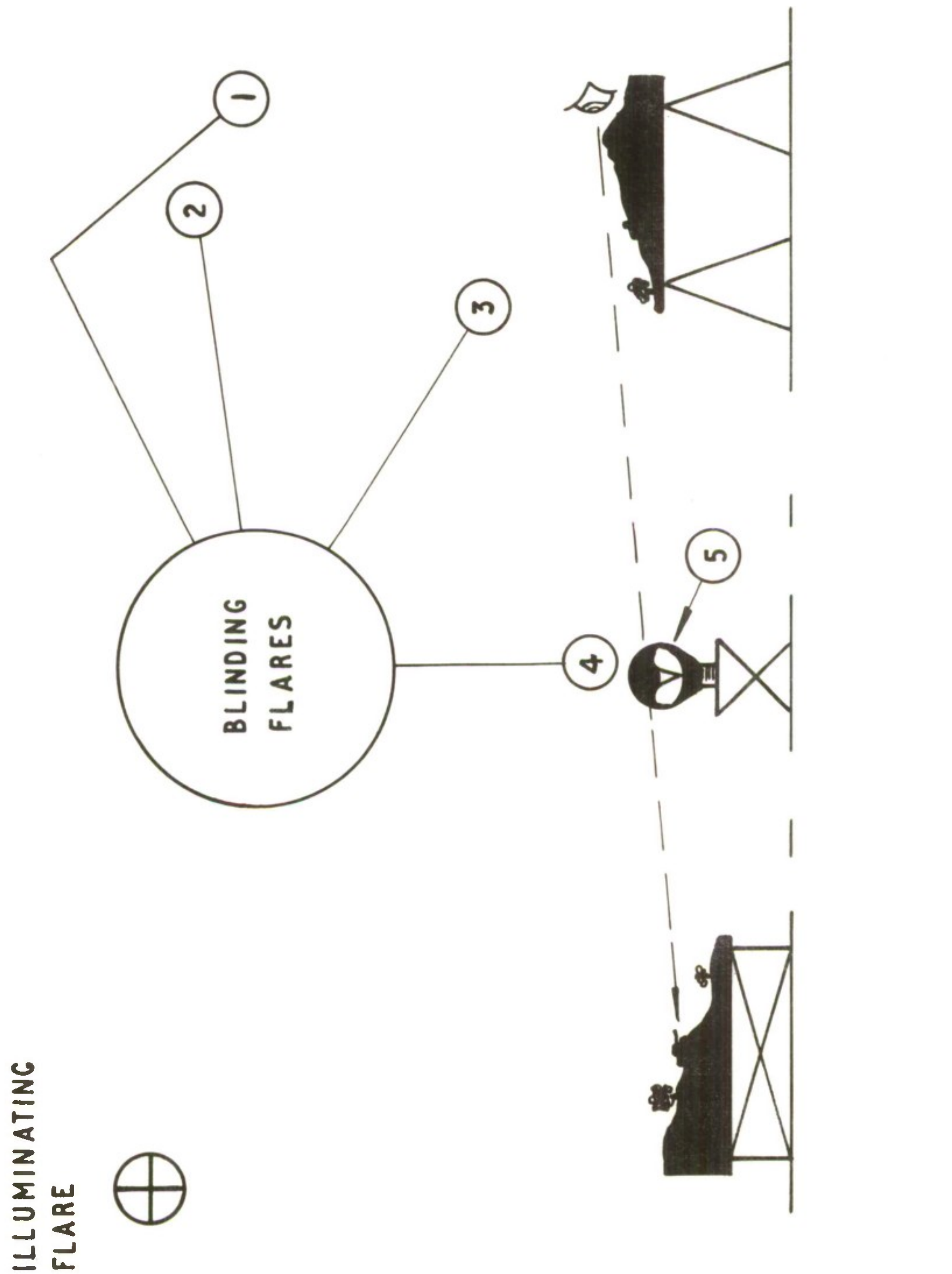

FIG.9 COUNTER - FLARE POSITIONS

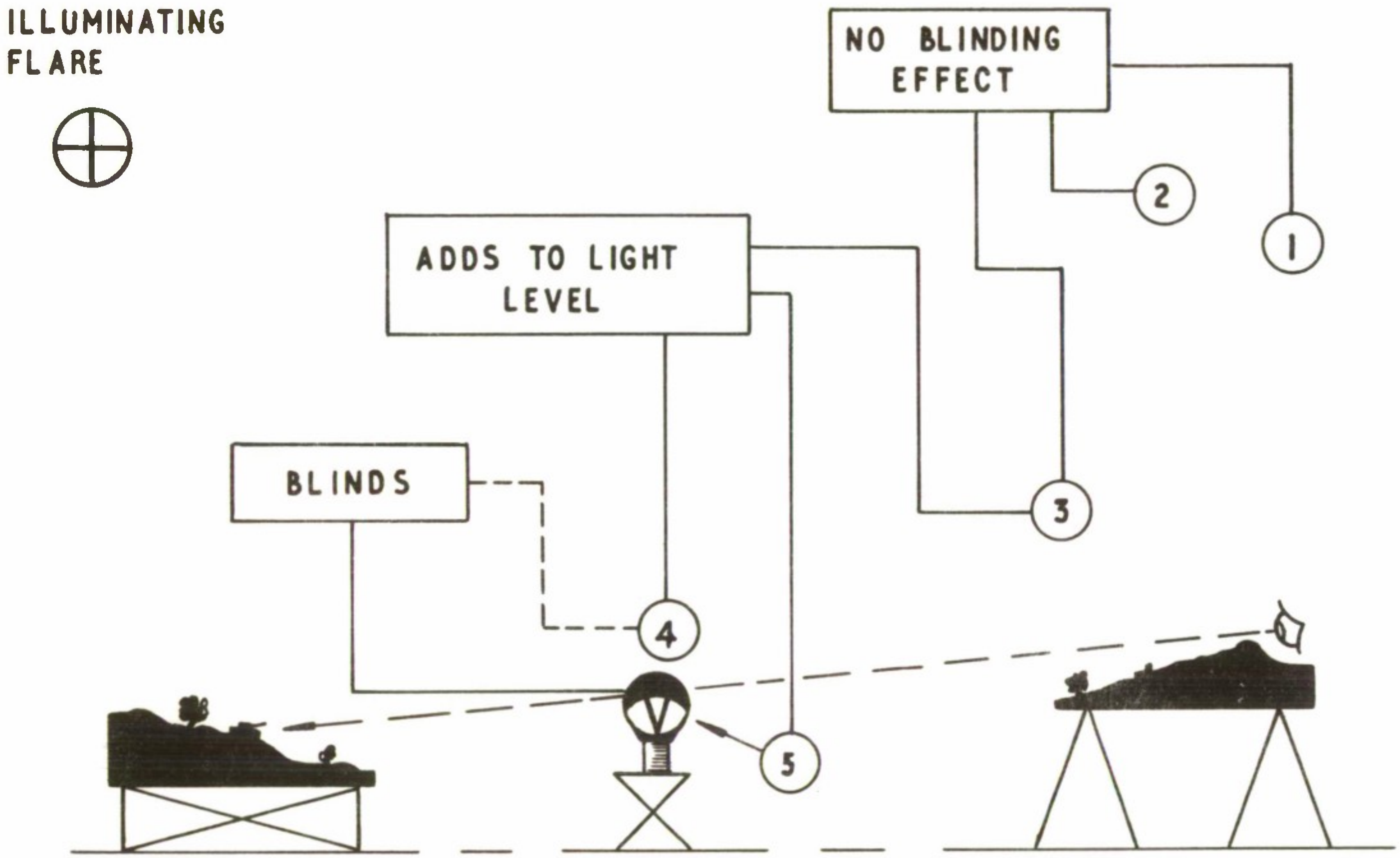

FIG. 10 EFFECTS OF COUNTER - FLARES

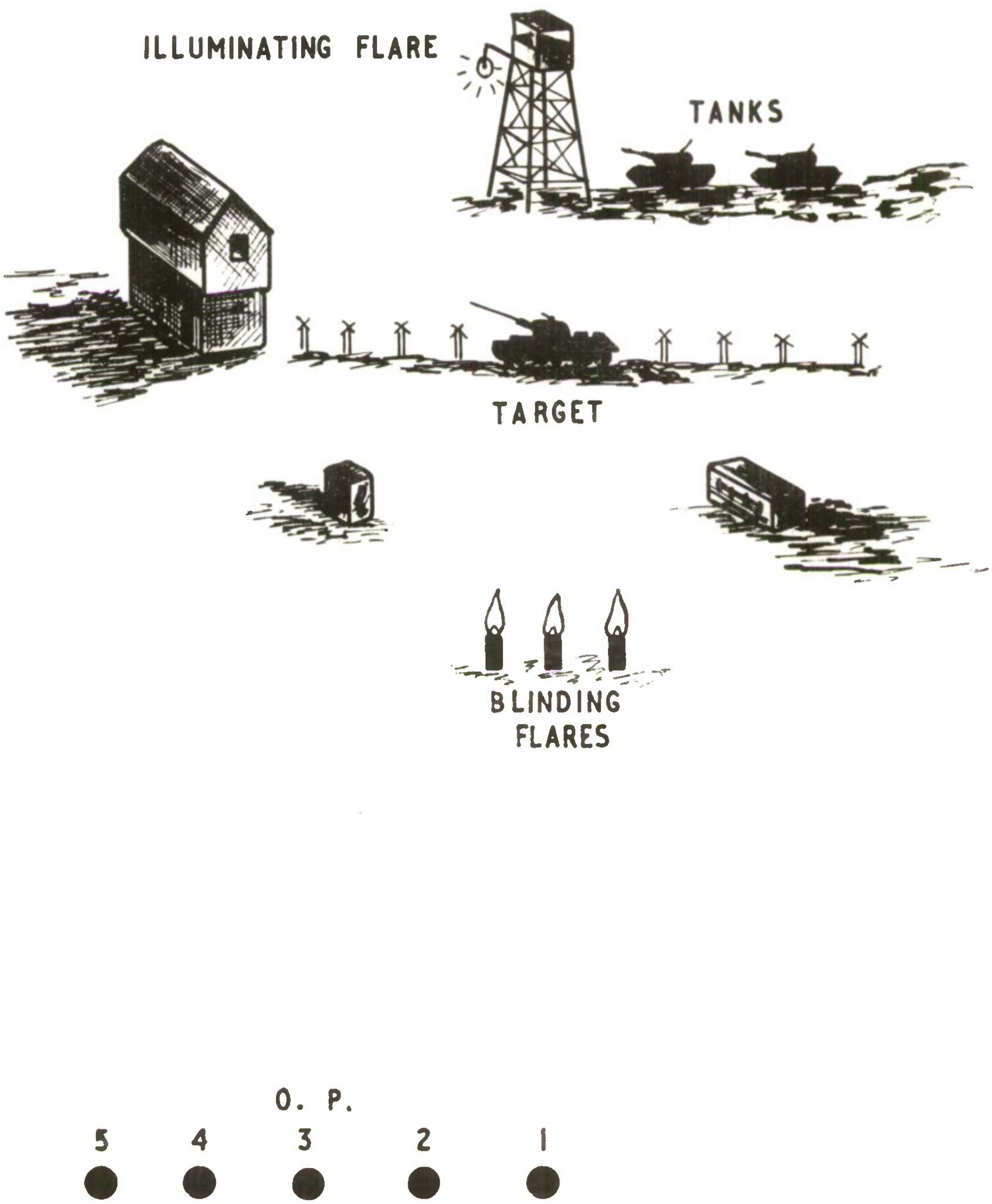

FIG. II DIAGRAMATIC LAYOUT OF FIELD TRIAL

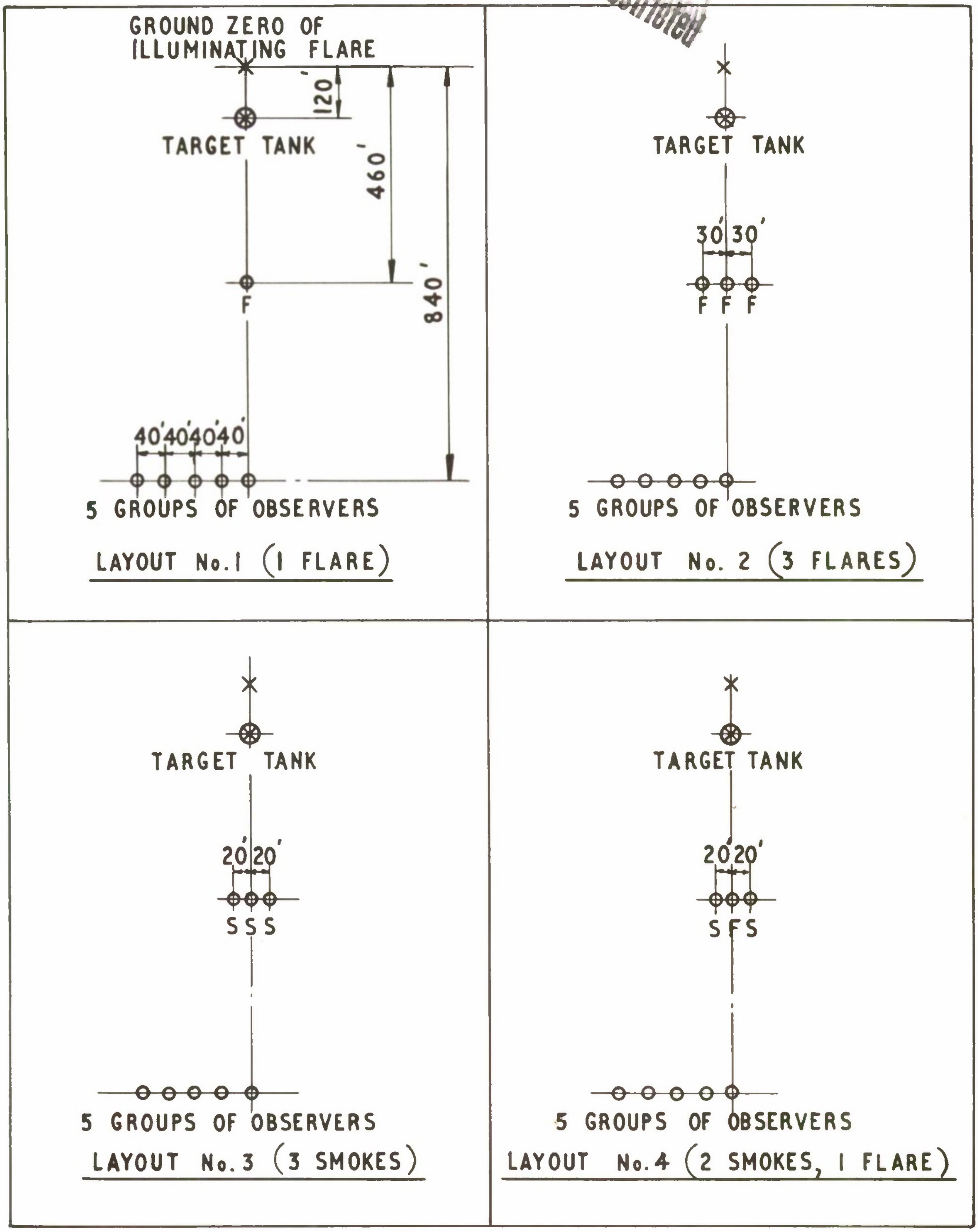

FIG. 12 LAYOUT OF BLINDING DEVICES FOR FIELD TRIAL

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R.A.R.D.E. Memorandum 34/69

623.454.42:
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Blinding flares - A model study of a battlefield illumination problem.

N. R. Williams, M. Budgen

August 1969

The Night War Game Series 1967 postulated a technique for blinding defence positions on the night battlefield. This report describes the work done, using models, which disproved the practical feasibility of this technique. The model approach was then used to determine effective methods of blinding on the battlefield and field trials carried out to enlarge on these methods. Recommendations are made for further work along the same lines, and also work to help in the design of more effective pyrotechnics generally by using models in conjunction with other techniques.

23 pp. 12 figs. 8 tabs. 4 refs.

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